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5 **Field of the Invention**

10 More particularly, the present invention relates to an image process apparatus for decreasing a color noise, an image process apparatus adopting the above method, and a storage medium storing a program to execute the above method.

In recent years, as hard-copy technology, especially a full-color hard-copy technology, develops, an excellent image reproduction can be achieved by using printing technology such as an inkjet recording system and the like and a high-pixel digital camera. By recording materials and image processes, color reproduction evolves up to extent by which digital photographing provides with an equal reproduction ability with silver bromide photographing.

25 However, there is a drawback that a color noise
due to a characteristic of an image pickup element or
the like in an input apparatus might be included in the

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with simple structure.

However, when such the conventional color noise elimination as above is applied to an image signal, apparent (or seeming) resolution of texture on the image not detected easily only by the edge from the brightness signal might be deteriorated. Further, when chromaticity of an attentional color noise is greatly different from surrounding chromaticity, there is a problem that it is necessary to repeat a color noise elimination process several times for the notable pixel.

In recent years, from the viewpoint of desirable color reproduction, an input image is first analyzed by a printer driver or the like, and processes such as brightness correction, saturation (or chroma) emphasis and the like are performed to the input image itself in accordance with the analysis result. For example, Japanese Patent Application Laid-Open No. 10-200777 describes that an image is first analyzed, and then a process for appropriate saturation correction is performed.

Further, when an image taken by a low-pixel digital camera is printed, such the printed image might be overshadowed by the printed image taken by the above high-pixel digital camera, whereupon a method of enlarging or expanding the input image to a suitable size by using anti-aliasing technique such as a bicubic

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manner, a nearest neighbor manner or the like is known.

Further, the noise such as the color noise or the like due to the dark current in the CCD element is included in the digital camera image. In color reproduction based on a subtractive color mixture system used in a hard copying machine, a gray line is very unstable frequently, and gradation is occasionally reversed around the gray line. Thus, since the color which should be originally the gray replaces the color around the gray line because of a color noise, there is a problem that it becomes easy for such the reversal part as above to appear on the printed image.

As a process to reduce the color noise, a color noise reduction process to divide a video signal into a brightness signal and a color difference signal in a TV set and clip the amplitude in the frequency band corresponding to the color noise part of the color difference signal is known.

However, if the image correction processes such as the brightness correction, the saturation emphasis and the like according to the analysis result, the enlargement process and the noise reduction process are combined, following problems are caused.

Namely, since the saturation of the entire image is emphasized according to the image correction processes such as the saturation emphasis and the like, the effect of the color noise reduction process might

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not be able to be demonstrated about the emphasized color noise part.

Further, since the input image is subjected to the enlargement process, the effect of the color noise reduction process might not be able to be demonstrated about the enlarged color noise part.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an image process method capable of achieving high-level color noise reduction without deteriorating apparent (or seeming) resolution for a color signal, an image process apparatus adopting this method, and a storage medium storing a program to execute this method.

In order to achieve the above object, the present invention provides an image process method comprising: an input step of inputting color image data composed of a signal representing brightness and a signal representing tint; and a smoothing process step of performing a smoothing process to the signal representing tint, while holding the signal representing brightness.

Another object of the present invention is to be able to effectively perform a color noise reduction process, and to be able to effectively perform the color noise reduction process and an image correction process.

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In order to achieve the above object, the present invention provides an image process method comprising: a calculation step of calculating a feature quantity of an input image; a color noise reduction process step of performing a color noise reduction process to input
5 image data; and an image correction step of performing a correction process to the input image subjected to the color noise reduction process, on the basis of the calculated feature quantity.

10 Still another object of the present invention is to be able to effectively perform the color noise reduction process and an image scaling process.

In order to achieve the above object, the present invention provides an image process method comprising:
15 a color noise reduction process step of performing a color noise reduction process for input digital image data; and a scaling step of scaling an image size, wherein the order of the color noise reduction process step and the scaling step is controlled in accordance
20 with a scaling rate or a scaling method.

Other objects and features of the present invention will become apparent from the following detailed description and the attached drawings.

25 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram schematically showing an image process apparatus 100 according to the first

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embodiment of the present invention;

Fig. 2 is a block diagram showing a printer driver 103 in the first embodiment;

Fig. 3 is a block diagram showing an image
5 correction process unit 120 in the first embodiment;

Fig. 4 is a flow chart showing an operation of a color noise reduction process which is performed by the image correction process unit 120 in the first embodiment;

10 Fig. 5 is a diagram showing an weight configuration of a low-pass filter;

Fig. 6 is a diagram showing a filter in which higher weight as compared with unprocessed signal values is allocated;

15 Fig. 7 is a diagram showing a filter in which high weight is allocated to pixels away from a notable pixel;

Fig. 8 is a flow chart showing an operation of the color noise reduction process which additionally
20 includes edge judgment and the like;

Figs. 9A, 9B and 9C are diagrams showing weight configurations of the low-pass filters;

Fig. 10 is a state transition chart showing a process sequence in a case where a scene change
25 judgment unit is provided, and the filter for processing the image is changed according to a position of a process target in an image;

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Fig. 11 is a diagram showing how to change the filter in the case where the filter for processing the image is changed according to the position of the process target in the image;

5 Fig. 12 is a diagram showing an image data division method in a case where image data is divided and then processed;

Fig. 13 is a diagram showing a lightness correction curve in case of lightness correction;

10 Fig. 14 is a diagram showing image data subjected to a filtering process with different tint for each divided area in case of dividing the image data, and an image division method;

15 Fig. 15 is a flow chart showing a suitable process procedure for each process in the first embodiment;

Fig. 16 is a flow chart showing a suitable process procedure for each process in the second embodiment;

Fig. 17 is a flow chart showing a suitable process procedure for each process in the third embodiment;

20 Fig. 18 is a diagram showing an example of a brightness histogram in a non-natural image such as a computer graphics (CG) image; and

25 Figs. 19A, 19B and 19C are diagrams showing an example of a brightness correction curve determination method.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[First Embodiment]

Fig. 1 is a block diagram schematically showing an image process apparatus 100 according to the first embodiment of the present invention.

For example, a printer 106 such as an inkjet printer or the like and a monitor 105 are connected to the image process apparatus 100 which includes a host computer.

The image process apparatus 100 includes, as software, applications 101 such as a word processor, a spreadsheet program, an Internet browser and the like, an OS (operating system) 102, a printer driver 103 which processes a group of various drawing instructions (an image drawing instruction, a text drawing instruction and a graphics drawing instruction) indicating output images issued to the OS 102 according to the applications and creates printing data, and a monitor driver 104 which processes the group of various drawing instructions and displays them on the monitor 105.

Further, the image process apparatus 100 includes, as various hardware which can execute the above software, a CPU (central process unit) 108, an HD (hard disk driver) 107, a RAM (random-access memory) 109, a ROM (read-only memory) 110, and the like.

As for the image process apparatus 100, for

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printer driver 103, an image correction process is performed sequentially to the drawing instructions issued from the OS 102, and the processed drawing instructions are sequentially rasterized to an RGB (red, green and blue) 24-bit page memory. After all the drawing instructions are rasterized, the content of the RGB 24-bit page memory is converted into a data format printable by the printer 106 such as C (cyan), M (magenta), Y (yellow) and K (black) data, and the converted data is then transferred to the printer 106.

Next, the process operation of the printer driver 103 in the present embodiment will be explained.

Fig. 2 is a block diagram showing the printer driver 103 in the present embodiment.

The printer driver 103 is composed of an image correction process unit 120 and a correction process unit for the printer (hereinafter called a printer correction process unit) 121.

By the image correction process unit 120, an image correction process is performed to color information included in the group of drawing instructions input from the OS 102. In this image correction process, a color noise reduction process is performed based on the R, G and B color information.

In the printer correction process unit 121, the drawing instructions are first rasterized based on the color information subjected to the image correction

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5 Next, the color noise reduction process in the
image correction process unit 120 will be schematically
explained.

Fig. 3 is a block diagram schematically explaining
10 the process of the image correction process unit 120.

20 In the present embodiment, a color noise is reduced by smoothing an rapid (or abrupt) change of the color difference signal while holding the brightness signal.

Next, the operation to reduce the color noise by
smoothing the rapid change of the color difference
signal while holding the brightness signal will be
explained.

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configuration of the low-pass filter.

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and $Cb(i, j)$.

time, as described in Japanese Patent Application No.

11-189637, it only has to perform an appropriate process for such the image periphery edge part.

In the present embodiment, the signal Y, Cr and Cb based on the NTSC (National Television System

5 Committee) format are used. However, instead of the brightness signal, for example, the G signal from among the R, G and B signals may be used. Further, as the chromaticity signals, the signals $Cr' = R/(R+G+B)$, $Cb' = B/(R+G+B)$ and the like may be used.

10 Even if the noise reduction process is performed by using an L*a*b* coordinate system, a Yxy coordinate system or the like, it is possible to obtain the same effect as above. Further, it is thought to perform the same process as above for an L*c*h* cylindrical
15 coordinate system, an HLS cylindrical coordinate system or the like. In this case, it is possible to perform the smoothing process after converting the coordinate values in the cylindrical coordinate system into the values in an orthogonal coordinate system.

20 Further, if it is enough that only color distortion has to be corrected, it is possible to perform the smoothing process to a change in hue angle. Similarly, even if the saturation is subjected to the smoothing process, it is possible to obtain the same
25 effect as above.

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$$f(i, j) = \tilde{f}(i, j) \quad \dots \quad (6)$$

In another example, after executing the equation (5), as shown in the above equation (6), the value after the smoothing of the color difference signal is fed back to the side of the original image signal. By doing so, it is possible to further increase the smoothing effect.

In case of performing such a feedback process as above, as shown in Fig. 6, it is possible to use a filter in which higher weight is allocated to the processed signal value as compared with the unprocessed signal value. By doing so, it is possible to further increase the smoothing effect of the color difference signal.

Further, by configuring the weight of the filter used in Fig. 6 and the like such that its denominator becomes the power of 2, it is possible to use a shift operation mechanism of a register and thus perform a high-speed increment process.

The filter is not limited to have the 5×5 size and to be symmetrical in the upper and lower directions and the right and left directions. Namely, if it is a filter having a low-pass filtering characteristic, it is possible to obtain the same color noise reduction effect. Of course, even if a median filter is used, it is possible to obtain the same effect as above.

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Further, it is possible to suitably change a filter size according to image resolution. By changing the filter size, it is possible to obtain a stable process result irrespective of the image resolution.

5 With respect to a real space, a real-time area and a spatial frequency area, by performing a process for decreasing a high frequency component to the signals except for the brightness signal Y, it is possible to obtain the same effect as above.

10 Fig. 4 is a flow chart showing the operation of the color noise reduction process.

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15 The color noise reduction process is performed to the image data part in the identical image indicated by the image drawing instruction. Therefore, for example, if a graphic and an image are included in the identical image, the image part is extracted according to an analysis result of the drawing instruction, and the color noise reduction process is then performed.

20 By only the color noise reduction process, apparent (or seeming) resolution might be deteriorated at an edge part of brightness and a color edge part where rapid chromaticity change is felt. Thus, in the present embodiment, edge judgment by an edge judgment unit, color edge judgment by a color edge judgment
25 unit, edge emphasis by an edge emphasis unit and the like are added to prevent the deterioration of the apparent resolution at the color edge.

(Edge Calculation Unit)

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It is possible to set the threshold value TH_Edge for each process target by analyzing the histogram of the input image or the like. In this case, for

5 obtaining the histogram for the frame memory storing
the differentiation value, analyzing the obtained
histogram with technique such as a discrimination
analysis method or the like, and clustering the pixel
values. Thus, a histogram calculation/analysis unit is
0 necessary.

15 the flow advances to edge emphasis (S5). If the
deterioration of the apparent resolution is not assumed
to be a problem, it is possible to omit this edge
emphasis step.

20 In the edge emphasis unit, the edge emphasis is performed by adding a brightness signal value $Y(i,j)$ to the held value $DY(S5)$.

$$25 \quad Y'(i, j) = Y(i, j) + D Y \quad \dots (1)$$

By performing the edge emphasis after or together with the color noise reduction, it is possible to

perform the edge emphasis without emphasizing color noises.

Here, speed-up and simplification of the process are achieved by performing the edge emphasis with the data obtained for the edge judgment. However, it is possible to perform the edge emphasis in other steps in the flow chart of Fig. 4.

In a case where the edge emphasis has been already performed on the side of an input apparatus, the edge emphasis need not be performed at this step.

Further, without performing the edge emphasis, it is possible to pass the data of the original image without processing it for the edge area composed of one or more pixels including the notable pixel. In this case, it is possible to perform faithful original image reproduction for the image area other than the color noise area.

(Chromaticity Change Judgment Unit)

In the chromaticity change judgment unit, a "color edge" (a rapid change part of the chromaticity) which can not be detected from the change of the brightness signal Y is detected (S3).

$$\begin{aligned} & D_col_CrL(i, j) \\ &= | \{ Cr(i-2, j-1) + Cr(i-1, j-1) + Cr(i, j-1) \} \\ &\quad - \{ Cr(i+2, j+1) + Cr(i+1, j+1) + Cr(i, j+1) \} | \\ &\dots (2) \\ & D_col_CrR(i, j) \end{aligned}$$

$$\begin{aligned} &= | \{Cr(i+2,j+1) + Cr(i+1,j+1) + Cr(i,j+1)\} \\ &\quad - \{Cr(i-2,j-1) + Cr(i-1,j-1) + Cr(i,j-1)\} | \\ &\quad \dots (3) \end{aligned}$$

Like the above, the color edge for the Cb
5 component is obtained.

$$\begin{aligned} &D_col(i,j) \\ &= D_col_CrL(i,j) + D_col_CrR(i,j) + D_col_CbL(i,j) \\ &\quad + D_col_CbR(i,j) \quad \dots (4) \end{aligned}$$

Here, the above calculated value $D_col(i,j)$ is
10 compared with a threshold value TH_col for the
chromaticity change judgment, whereby the chromaticity
change judgment is performed.

Though the threshold value TH_col is fixed in the
above embodiment, it is possible to calculate a feature
15 quantity of the histogram of the input image and
perform the chromaticity change judgment based on the
calculated feature quantity. Further, even if the
value $D_col(i,j)$ is calculated by using the
differentiation value of the color difference signal,
20 it is possible to obtain the similar effect. It should
be noted that the automatic setting method of the
threshold value TH_col here only has to properly use
the technique such as the discrimination analysis
method or the like described in the above edge
25 judgment.

Further, in the chromaticity change judgment
process of the present embodiment, the color noise part

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In the first embodiment, the input image data

However, after such the edge judgment or the chromaticity change judgment, the junction (tie part) of the edge part and non-edge part might stand out too much.

$$E(i,j) = D_Y(i,j) \times H(D_Y(i,j) - TH_Edge)/TH_Edge \quad \dots (7)$$
$$\begin{aligned} & \text{Col}(i,j) \\ &= E(i,j) \times \text{Col}(i,j) + (1 - E(i,j)) \times \text{Low}(\text{Col}(i,j)) \\ & \dots (8) \end{aligned}$$

Here, $H(\cdot)$ denotes a Heaviside step function, and $\text{Low}(\cdot)$ denotes the low-pass filter.

25 The color noise frequently stands out in a low-saturation area. Thus, a saturation $S(i,j)$ ($= \sqrt{Cr^2 + Cb^2}$) of the notable pixel is calculated.

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If the color noise degree is defined by a rate

$$C_n(i, j)$$

$$5 \quad = |(\text{Col}(i,j) - \text{med}(\text{Col}(i,j)))| / (|\text{med}(\text{Col}(i,j))|) \quad \dots (9)$$

10 For data of which color noise degree $C_n(i,j)$ is
high, a filter shown in Fig. 7 in which high weight is
allocated to the pixels away from the notable pixel is
used to perform the color noise reduction process.
Thus, it is possible to obtain a higher color noise
15 reduction effect.

Here, the target area which is used to calculate the intermediate value `med(.)` may be an area having any shape and size if such the area includes the notable pixel. Further, even if an average value is used

20 instead of the intermediate value `med(.)`, it is possible to obtain the same effect as above.

Here, in order to avoid descriptive complexity, the same steps as those in the first embodiment are added with the same symbols and the explanation thereof will be omitted.

Fig. 8 is a flow chart showing the operation of

the color noise reduction process according to the present embodiment.

(Highlight Judgment Unit)

5 A hard copying apparatus such as an inkjet printer or the like adopts a method of substituting paper white as white. For this reason, a white part ($R = G = B = 255$) is the paper white, but, e.g., dots are emitted onto a non-white part by the Inkjet printer. Thus, tint is similar between the above two cases, but
10 presence of the dots might be felt discontinuous.

Fig. 14 is a diagram showing image data subjected to a filtering process with different tint for each divided area in case of dividing the image data, and an image division method.

15 In any case, as shown in Fig. 14, in a case where a white block 11 and a block 12 which is essentially the white block but partially includes a non-white texture exist (called a non-white block hereinafter), if the notable pixel and its peripheral pixels are
20 smoothed by the color noise reduction process, tint might be slightly different between the white block and the non-white block. Namely, the white block is the paper white, but the dots might be emitted to the non-white block.

25 Thus, in the highlight judgment unit, it is judged whether or not one point is the paper white (S11). Then, the color noise reduction process is not

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performed to the point judged to be the paper white (S6). As a highlight judgment method used here, it is possible to appropriately use a method of judging highlight such as "(R \geq 250)AND(G \geq 250)AND(B \geq 250)", "Y \geq 250", or the like.

Further, there is a case where it is intended, after the color noise reduction process, to perform an image process such as a lightness correction process or the like by using a lightness correction curve shown in Fig. 13. Also in this case, like the above, the pixel which essentially has the pixel value "234" is changed to have the pixel value "234" or "236" because of the smoothing in the color noise reduction process, whereby a band unevenness part occurs between the paper white part and the dot-emitted part.

In this case, a highlight point HL is obtained from the above determined lightness correction curve (S11), and it only has not to perform the color noise reduction process to the pixels of the pixel values in the vicinity of the highlight point HL (S6).

Further, in a printer such as a sublimation printer or the like capable of sufficiently expressing gradation, the above band unevenness is not so remarkable. In such a case, it is possible not to perform the above highlight judgment process.

By only the color noise reduction process, apparent (or seeming) resolution might be deteriorated

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Th#ColDiff#Line, it is considered that the input image data to such an image process module as above is uncontinuous, whereby such the input image data is detected as an uncontinuous point (S12).

5 In the present embodiment, a kind of filter is changed on the basis of the positional relation between the line detected as the uncontinuous point and the target image data.

10 Figs. 9A, 9B and 9C are diagrams showing the weight configurations of the low-pass filters. Namely, Fig. 9A shows the filter for a three-line process, Fig. 9B shows the filter for a two-line process, and Fig. 9C shows the filter for a one-line process.

15 Fig. 10 is a state transition chart showing a process sequence in a case where the scene change judgment unit is provided, and the filter for processing the image is changed according to a position of the process target in the image.

20 Fig. 11 is a diagram showing how to change the filter in the case where the filter for processing the image is changed according to the position of the process target in the image.

25 As shown in Fig. 11, in the color noise reduction process, when the first line of the input image is processed, the smoothing of the color difference signal is performed by the filter of Fig. 9C with use of only the first line of the image (L1 in Fig. 11, P1 in Fig.

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10). When the second line of the input image is processed, the smoothing of the color difference signal is performed by the filter of Fig. 9B with use of the second line of the image and the first line above the second line by one (L2 in Fig. 11, P2 in Fig. 10).

When the third line of the input image is processed, the smoothing is performed by the filter of Fig. 9A with use of the third line of the image, the second line above the third line by one, and the first line above the third line by two (L3 in Fig. 11, P3 in Fig. 10) (S13).

Namely, when the uncontinuous point of the input image data is detected in the interlinear color different judgment unit, as shown by symbols T21 and T31 in Fig. 10, the filtering process area is changed from the current three-line process of P3 in Fig. 10 or the two-line process of P2 in Fig. 10 to the one-line process of P1 in Fig. 10. This is called a memory refresh operation after band change judgment.

By performing the filtering process with use of such the filter structure, for example, as shown in Fig. 12, even when one image data is divided by the application and input to the image process module, it is possible to perform the appropriate filtering process. Here, numerals 1 to 10 in Fig. 12 denote a range of the image data which is divided and input to the image process module. Further, each pair of upward

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and down ward arrows shown in Fig. 11 denotes a range of the image data used when the notable line indicated by a white circle is smoothed.

Further, by performing the filtering process with use of such the filter structure, the output is obtained every time the image data is input. Thus, it is possible to perform the filtering process that a delay is not caused in the image data output after the process.

When the average color difference is obtained, the average color difference need not necessarily be an accurate color difference. For example, it is possible to appropriately perform sampling for the ten pixels of the notable line on the image and then use the average color difference obtained for such the ten pixels. Further, it is possible to obtain the color difference by using, e.g., only the R component of the R, G and B data or only the Y component of the Y, Cr and Cb data. [Fourth Embodiment]

In the present embodiment, the process which is performed by the image correction process unit 120 in Fig. 2 when an enlargement process is performed to the input image will be concretely explained.

It should be noted that the structure of the image process apparatus is the same as explained in the above other embodiments.

The process procedures of image feature quantity

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5 Each of the above image processes is performed to
the image data part concerning the identical image
indicated by the image drawing instruction. Therefore,
for example, if a graphic and an image are included in
the output image, the image part concerning the
0 identical image is extracted, and the image process
shown in Fig. 15 is performed.

In the present embodiment, the processes are performed in the order shown in Fig. 15 to be able to properly obtain the color noise reduction effect.

In the image feature quantity calculation unit of a step S61, as the feature quantity of the image part, on the basis of the input image data at the image part, a brightness histogram is first created, and a highlight point HL, a shadow point SD and the number of colors are calculated. Further, a saturation signal is created from the color difference signal, and an

In the present embodiment, the saturation signal is created from the color difference signal according to an equation $S = \sqrt{Cr^2 + Cb^2}$.

5 Here, if the size of the process-target image is
large, it is possible to obtain the image feature
quantity by appropriately sampling reference points
from the target image. In the present embodiment, for
example, 10000 reference points are selected in the
10 input image data of 1600 × 1200 pixels, and various
histograms are obtained for such the selected reference
points. Here, as a reference point selection method,
for example, there is a method of setting a sampling
interval in the image lateral direction to 1600Mod(100)
15 pixels and a sampling interval in the image
longitudinal direction to 1200Mod(100) pixels, and
scanning the target image with the respective sampling
intervals to obtain the image feature quantity.

It should be noted that, as the image feature quantity obtained in the step S61, it is possible to calculate another feature quantity such as a saturation histogram or the like if such the feature quantity accords to a condition used in each process later described.

25 (Natural Image Judgment Unit)

The image indicated by the raster data command includes a computer graphic or the like of which

characteristic is different from that of a natural image such as a portrait and a scenic. For example, since the computer graphic is the image created by using the application, to begin with any color noise does not exist. Further, if the later-described color noise reduction process is performed to a gradation image such as the computer graphic or the like, deterioration of coordination might occur.

Similarly, if the later-described lightness and saturation correction process is performed to the gradation image such as the computer graphic or the like, deterioration of coordination might occur in the vicinity of highlight, in the vicinity of darkness, at a high-saturation part, or the like.

Accordingly, in the present embodiment, in the natural image judgment unit of a step S62, it is judged based on the image feature quantity obtained by the image feature quantity calculation unit of the step S61 whether or not an image kind of the process-target image judged to be the image based on the drawing instruction is a natural image, and it is controlled not to perform the later-described color noise reduction process and lightness and saturation correction process to the natural image. Conversely, if judged that the image kind is not the natural image, the flow advances to a step S66.

Here, as shown in Fig. 18, the used colors tend to

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be biased in an artificial gradation image such as the computer graphic or the like. Thus, the natural image judgment pays attention to this tendency and thus selects a non-natural image based on whether or not the distribution of the brightness histogram is discrete. In the present embodiment, for example, if the number of used colors calculated by the image feature quantity calculation unit of the step S61 is smaller than a threshold value Th_Cols_Photo, the process-target image is judged to be the non-natural image.

In the present embodiment, the pseudo number of used colors obtained from the brightness histogram is used as the number of used colors. However, for example, it is possible to use the result obtained by counting different combinations of the brightness and color difference signals.

(Image Correction Method Determination)

In the image correction method determination unit of a step S63, the image correction method in the later-described lightness and saturation correction process unit is determined for the image judged to be the natural image by the natural image judgment unit of the step S62, by using as indexed the highlight point HL and the shadow point SD obtained in the image feature quantity calculation unit of the step S61.

(Brightness Correction Method Determination)

The brightness correction method will be briefly

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explained with reference to Figs. 19A, 19B and 19C.

If the brightness histogram of the process-target natural image is assumed to be shown in Fig. 19B, it can be understood from Fig. 19B that the brightness distribution of this natural image is biased to the center and thus this image has scarce gradation.

Thus, in order to improve the gradation of this natural image, a brightness correction curve is set as shown in Fig. 19A such that the highlight point HL and the shadow point SD become "255" and "0" respectively. (Saturation Correction Method Determination)

A stored color tends to be shifted to the higher saturation side as compared with the actual tint. Accordingly, in general color reproduction of a natural image, when a process to emphasize the saturation is performed, its presentation is good.

Thus, if the average saturation value S_{ave} obtained by the image feature quantity calculation unit of the step S61 satisfies $S_{ave} < Th_High_Saturation$, for example, a saturation emphasis process condition is set to raise the saturation by 20%.

In the present embodiment, the saturation signal is created from the color difference signal according to the equation $S = \sqrt{Cr^2 + Cb^2}$.

Then, the above saturation emphasis process is performed to the saturation signal S , and an inverse process of the above equation is performed to convert

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the saturation signal into the color difference signal.

It should be noted that it is possible to previously set the saturation emphasis process condition by a user, or to calculate the saturation emphasis process condition on the basis of the average saturation value Save.

(Color Noise Reduction Process Unit)

In the color noise reduction process unit of a step S64, the color noise reduction process as explained in the first to third embodiments is performed.

When the color noise is included in the process-target image, the color noise part might be emphasized by the brightness and saturation correction process or the later-described image enlargement process.

Further, even if the color noise reduction process is performed, the effect is not often achieved enough for the emphasized color noise part.

Thus, in the present embodiment, the color noise reduction process is first performed, and the brightness and saturation correction is performed to the image data after the noise reduction process.

As in the present embodiment, by the color noise reduction process to perform the smoothing process to color difference, there is a case where apparent resolution at the color edge part for brightness or at the color edge part where rapid chromaticity change is

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felt though brightness change is small is deteriorated.
Thus, in the present embodiment, edge judgment by the
edge judgment unit, color edge judgment by the color
edge judgment unit, edge emphasis by the edge emphasis
5 unit and the like are added to prevent the
deterioration of the apparent resolution at the color
edge.

(Brightness and Saturation Correction Process Unit)

The brightness and saturation correction process
10 unit of a step S65 will be explained.

As to the image data subjected to the color noise
reduction by the color noise reduction process unit of
the step S63, the brightness and color difference
signals are corrected in the step S65 on the basis of
15 the brightness correction method and the saturation
correction method obtained in the step S63.

Further, the brightness signal is corrected based
on the brightness correction curve obtained in the step
S63.

20 On the other hand, as to the saturation signal, if
judged in the step S62 that the average saturation
value S_{ave} is smaller than the threshold value
 $Th_High_Saturation$, a process according to the
saturation emphasis process condition set for the
25 saturation signal is performed to the color difference
signal.

$$Cr'' = 1.2 \times Cr'$$

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$$Cb'' = 1.2 \times Cb'$$

According to the present embodiment, it is possible to perform the brightness and saturation correction process with use of the brightness signal Y and the color difference signals Cr and Cb used in the color noise reduction process unit as it is. Namely, it is possible to perform the color noise reduction process and the brightness and saturation correction process efficiently.

In the present embodiment, the lightness correction is performed based on a lookup table, and the saturation correction is performed based on simple calculation, whereby a high-speed process is achieved.

When a color palette dedicated for the image data exists, the color conversion (lightness and saturation correction) is performed to the color palette to perform the lightness and saturation correction process in the block, whereby a high-speed process is achieved. (Image Enlargement Process: Anti-Aliasing Process)

Next, an image scaling process (anti-aliasing process) in the step S66 will be explained.

When a digital camera image is printed and output by the inkjet printer, since the digital camera image is the image at monitor resolution level, it is necessary when the digital camera image is output by the inkjet printer to convert the resolution of this image into resolution by which one nozzle of an ink

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process is finally performed. By doing so, it is possible to reduce the number of color noise reduction processes and lightness and saturation correction processes, whereby an efficient process is achieved.

5 In the present embodiment, the color noise reduction process and the brightness and saturation correction process are performed to the luminance and color difference signals. Besides, such a color noise reduction process and a brightness (lightness) and saturation correction process as above can be performed to an image signal indicated by a signal representing brightness and a signal representing tint. For example, it is possible to use a CIE $L^*a^*b^*$ system, or use the G component of R, G and B signals as the signal representing brightness and $Cr' \Delta R / (R+G+B)$, $Cb' \Delta B / (R+G+B)$ as the signal representing tint.

15 Further, it is possible to use a cylindrical coordinate system such as $L^*c^*h^*$ system, an HLS system or the like. In case of using the cylindrical coordinate system, it is possible to perform the smoothing after converting the coordinate values in the cylindrical coordinate system into the values in an orthogonal coordinate system. Further, when it is enough to correct only color distortion, it is possible to perform the smoothing to a change in hue angle.

25 Further, when the edge emphasis process is premised, or when the deterioration of the apparent

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resolution is not assumed to be a problem, it is possible to omit the edge judgment process and the edge emphasis process.

Further, when the process by which the "color edge" is emphasized is performed to the image after the color noise reduction process, it is possible to omit the process by the chromaticity change judgment unit.

Further, it is possible to control whether or not the color noise reduction process should be performed based on a user's manual instruction, and to control the color noise reduction process to be performed according to the result of the above judgment process. [Fifth Embodiment]

In the above fourth embodiment, it was assumed that the digital camera image is printed and output, and the case where the input image is subjected to the enlargement process was explained. However, according to circumstances, an image reduction process is performed. In such a case, since the process-target image can be reduced in size by the image reduction process, it is unnecessary to perform the process at the end. Namely, it is possible to perform the image reduction process, the color noise reduction process, and then the lightness and saturation correction.

As above, when a scaling rate of the input image has been previously known, it is possible to adaptively determine the order of the image scaling process and

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Further, when the output image is small, it is necessary to perform a thinning process to the input image. In the thinning process, when the thinning is performed by interpolation with use of the signal values of the peripheral pixels around the notable pixel, the tint of the image after the reduction process might be different due to the color noise on the image. In such a case, in consideration of quality of the output image, it is desirable to perform the color noise reduction process, the image reduction process, and finally the lightness and saturation correction.

20 As above, in case attaching importance to the
quality of the output image, it is desirable to
determine the order of the image processes on the basis
of the scaling rate of the image scaling process, the
size of the output image, and the scaling method. It
25 should be noted that, even if all of the above three
conditions are not considered but only one condition is
considered to control the order of the image processes,

it is possible to obtain the similar effect.

[Sixth Embodiment]

The sixth embodiment of the present invention will be explained with reference to Fig. 16. Hereinafter, in order to avoid explanatory complexity, the explanation of the same steps as those in the above embodiments will be omitted, and process procedures will be briefly described.

On the basis of the feature quantity obtained by the image feature quantity calculation unit of a step S71, it is judged in a step S72 whether or not the target image is the natural image. Then, in a step S73, the color noise reduction process is performed to the image judged to be the natural image.

Further, the image feature quantity for the image data of which color noise has been reduced is again calculated by the image feature quantity calculation unit of a step S74. Then, by using the again-calculated image feature quantity, the lightness and saturation correction method is determined by the image correction method determination unit of a step S75.

Since the color noise is easily generated in a low-lightness part, it is possible that the shadow point SD shifts from the essential shadow point.

However, by processing the image according to the process procedure of the present embodiment, it is possible to perform the image correction process with

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use of the more accurate shadow point SD, whereby it is possible to obtain a suitable processed result.

[Seventh Embodiment]

5 The seventh embodiment of the present invention will be explained with reference to Fig. 17. Hereinafter, in order to avoid explanatory complexity, the explanation of the same steps as those in the above embodiments will be omitted, and process procedures will be briefly described.

10 In the seventh embodiment, when the image correction process is not performed for the non-natural image, it is possible to omit the image feature quantity calculation unit of the step S71 and the natural image judgment unit of the step S72.

15 For example, when it is possible to previously discriminate the natural image data from the non-natural image data such as the computer graphic or the like on the side of the printer driver 103 shown in Fig. 2, it is possible to omit the above units.

20 [Other Embodiments]

In the present invention, program codes themselves for causing an apparatus or system connected to various devices to operate them to achieve the functions of the above embodiments, and a means such as a storage medium storing the program codes for supplying the program codes to a computer constitute the present invention.

As the storage medium storing the program codes,

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for example, a floppy disk, a hard disk, an optical disk, a magneto-optical disk, a CD-ROM, a magnetic tape, a nonvolatile memory card, a ROM, or the like can be used.

5 It is needless to say that the present invention includes not only the case where the functions of the above embodiments are achieved by executing the supplied program codes with the computer, but also a case where the functions of the above embodiments are
10 achieved by executing the program codes with an OS (operating system) running on the computer or cooperation of the OS and other applications or the like.

 Further, it is needless to say that the present
15 invention includes a case where the supplied program codes are once stored in a memory provided in a function expansion board inserted in the computer or a function expansion unit connected to the computer, and then a CPU or the like provided in the function
20 expansion board or the function expansion unit performs all or a part of the actual processes based on instructions of the program codes, whereby the functions of the above embodiments are achieved by such the processes.

25 Further, it is possible to appropriately combine the above plural embodiments.

 Although the present invention has been explained

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with the preferred embodiments, the present invention
is not limited to them. Namely, it is obvious that
various modifications and changes are possible in the
present invention without departing from the spirit and
5 scope of the appended claims.

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